FLRPC PD Recommendations and Charge to the PD Task Force

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Outline

- **FLRP:**
  - PD Considerations
  - PD recommendations
- **Directors Charge to the PD Task Force**

Fermilab:Long Range Planning

- **FLRP Committee recommendations:**
- **Plan A: LC was strongly endorsed**
  - Enlarged FNAL Role and Participation
  - Active “bid to host” LC on or near the FNAL site
  - But… realization that LC may not be sited at FNAL, or may be delayed
- **Plan B: Excerpt from the charge to the LRP committee:**

  “ I would like the Long-range Planning Committee to develop in detail a few realistically achievable options for the Fermilab program in the next decade under each possible outcome for the linear collider. ….“
- **It was clear from the start that a new intense proton source to serve long baseline neutrino experiments was one such option…**

FLRP:PD Working group

- **Had a series of 14 FLRPC PD subcommittee meetings**
  - Well attended by expert participants
  - FLRPC PD Subcommittee was “reinforced” with accelerator experts who served as advisors
  - The subcommittee reviewed the estimated protons needs of the approved FNAL Physics program
    - Finley: Proton Team report
  - Next we examined the likely proton demands of various possible future FNAL Physics programs
    - Dominated by the needs of long baseline neutrino experiments
  - Reviewed current limitations of existing P source & reasonable upgrades
    - Prebys: Proton Plan
  - Examined options for a new intense Proton Source
    - Chou & Foster: Synchrotron & SCRF linac options
- **Led to FLRPC Proton Driver Recommendations (Steve)**

Studies of the FNAL Proton Source

- **Several studies have had the goal of understanding the limitations of the existing source and suggesting upgrades**
- **Proton Driver Design Study I:**
  - 16 GeV Synchrotron (TM 2136) Dec 2000
- **Proton Driver Design Study II (draft TM 2169) :**
  - 8 GeV Synchrotron May 2002
  - 2 MW upgrade to Main Injector May 2002
  - 8 GeV Superconducting Linac: Feb 2004
- **Proton Team Report (D Finley):** Oct 2003
  - **Report:** http://www.fnal.gov/directorate/program_planning/studies/ProtonReport.pdf
  - **Limitations of existing source, upgrades for a few 10's of $ M.**
  - "On the longer term the proton demands of the neutrino program will exceed what reasonable upgrades of the present Booster and Linac can accommodate ➔FNAL needs a plan to replace its aging LINAC & Booster with a new more intense proton source (AKA a Proton Driver)

Proton Driver Design Studies

- **8 GeV Synchrotron (TM 2169)**
  - Basic plan is to replace the existing Booster with a new large aperture 8 GeV Booster (also cycling at 15 Hz)
  - Takes full advantage of the large aperture of the Main Injector
  - Goal= 5 times # protons/cycle in the MI ($3 \times 10^{13} \rightarrow 1.5 \times 10^{14}$)
  - Reduces the 120 GeV MI cycle time 20% from 1.87 sec to 1.53 sec
  - The plan also includes improvements to the existing linac (new RFQ and 10 MeV tank) and increasing the linac energy (400→600 MeV)
  - The increased number of protons and shorter cycle time requires substantial upgrades to the Main Injector RF system
- **Net result = increase the Main Injector beam power at 120 GeV by a factor of 6 (from 0.3 MW to 1.9 MW)**

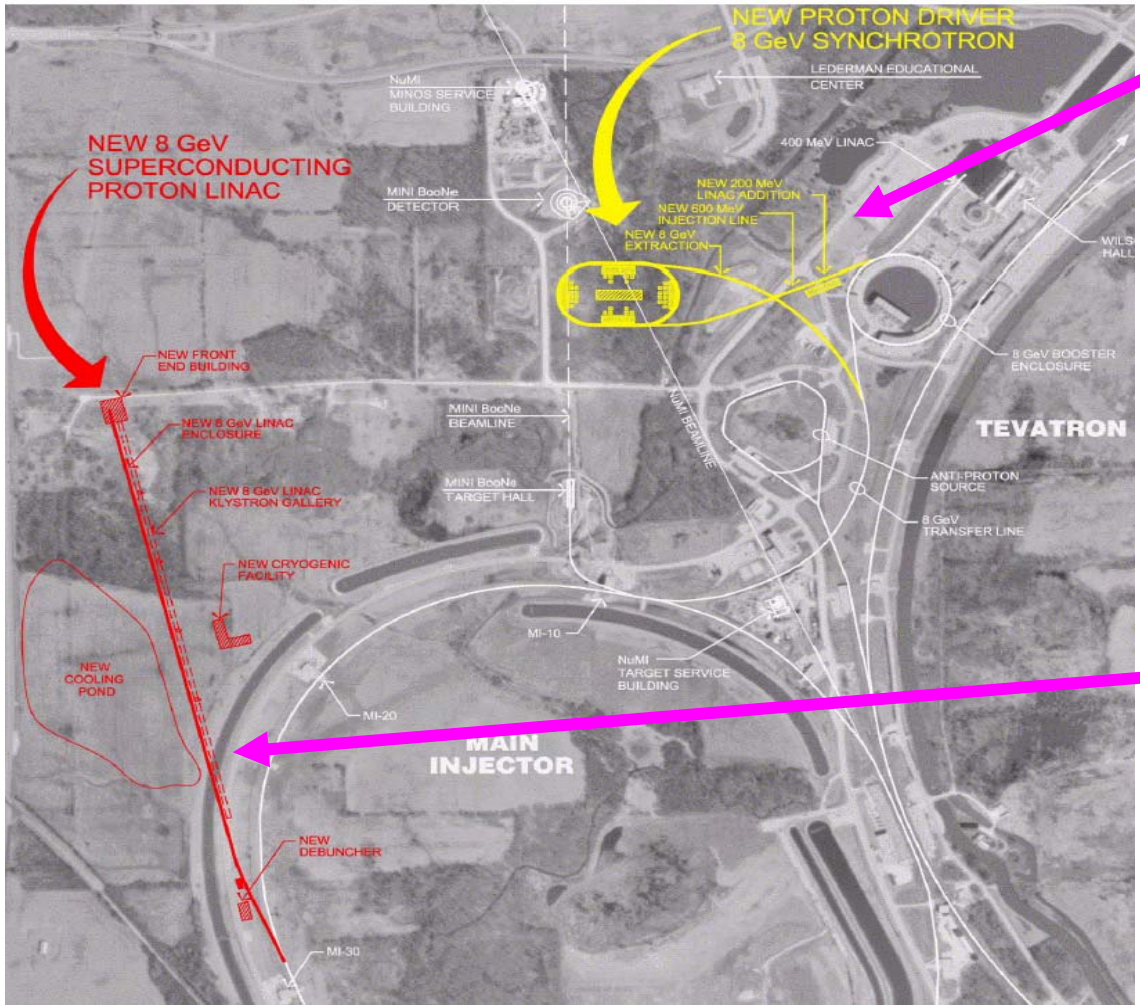
PD: 8 GeV Synchrotron

- **Synchrotron technology well understood**
  - We have more experience with this kind of machine
- **But…the plan in TM2169…**
  - Doesn't replace entire linac ➔ 200 MHz PA's would still be a vulnerability, aging linac equipment still an issue
  - Cycle time is still 15 Hz ➔it would still take 5/15 of a sec to fill MI with 6 booster batches➔ limits upgrades to the MI cycle time (Beam power is proportional to # p/cycle x cycles/sec)
  - Large aperture rapid cycling magnets➔development
  - Significant interruption of operations to upgrade linac and break into various enclosures (vs. Run II)
  - Losses, instabilities, etc… vs. ultimate performance ?

PD: 8 GeV SC Linac

- **Design concept originated with Bill Foster at FNAL**
- **Observation: $/ GeV for SCRF has fallen dramatically ➔Can consider a solution in which H- beam is accelerated to 8 GeV in a SC linac and injected directly into the Main Injector**
- **Why an SCRF Linac looks attractive:**
  - Many components exist (few parts to design vs new booster synchrotron)
    - RFQ+ DTL = AccSys products , ANL RIA spoke resonators ?
    - JLAB can design low beta 1.3 GHz elliptical cavities quickly
    - Use "TESLA" cavities & Cryo modules from 1.2 → 8 GeV
    - Use existing TESLA multi-beam 1.3 GHz Klystrons
  - Probably simpler to operate vs. two machines (i.e. linac + booster)
  - Produces very small emittances vs. a synchrotron (small halo and losses in MI)
  - Can delivers high beam power simultaneously at 8 & 120 GeV
  - Small transverse emittance linac beam is "phase space painted" into MI (40 π) aperture in 1 ms➔ MI "fill time" is negligible vs. MI ramp
  - Can be "staged" to limit initial costs & grow with neutrino program needs

Proton Driver Siting for Design Study



- **Synchrotron:**
  - Sited West of the existing booster
  - Increase shielding by factor of two
  - Larger apertures & collimators limit losses to avoid activation of equipment
- **SCRF LINAC**
  - Sited tangent to the Main Injector
  - H- beam, Low Halo
  - Small emittance beams
  - ➔ Low losses in MI

Other Possible SCRF Linac Missions

- **Principle Mission: Proton superbeams for Neutrinos**
  - 8 GeV or 120 GeV from MI (NUMI/Off-axis)
- **Also:**
  - Protons for future 120 GeV fixed target experiments and continued anti-proton production
- **Other possible missions:**
  - SCRF Infrastructure development for a cold technology LC
  - Could be made to accelerate electrons
    - Drive an x-ray FEL ?
    - LC beam studies ? Possibly serve as part of a LC ETF
  - Spallation Neutron source ?
  - Low emittance injector to a future VLHC ?

Technological Synergies

- **Lots of labs use or plan use of SCRF**
- **This provides many opportunities for collaboration and shared infrastructure/development costs**
- **Other Accelerators:**
  - Existing: ATLAS (ANL), CBEAF, FNPL, TTF-I (DESY)
  - Construction: SNS (ORNL), DESY FEL
  - Proposed:
    - Cold Technology Linear Collider (TESLA),
    - RIA (ANL)
    - Light sources: LUX (LBNL), Cornell light source, PERL (BNL),MIT
    - Electron cooling in RHIC (BNL), eRHIC (BNL)
    - BNL proton superbeam
    - SC linac is being discussed for the LHC upgrade
    - Medical isotope production, etc

FLRP PD Recommendations (skip)

- **We recommend that Fermilab prepare a case sufficient to achieve a statement of mission need (CD-0) for a 2 MW proton source (Proton Driver). We envision this project to be a coordinated combination of upgrades to existing machines and new construction.**
- **We recommend that Fermilab elaborate the physics case for a Proton Driver and develop the design for a superconducting linear accelerator to replace the existing Linac-Booster system. Fermilab should prepare project management documentation including cost & schedule estimates and a plan for the required R&D. Cost & schedule estimates for Proton Driver based on a new booster synchrotron and new linac should be produced for comparison. A Technical Design Report should be prepared for the chosen technology.**

Proton Driver Charge from the Director

To: Bill Foster and Steve Geer
From: Michael Witherell
Subject: Next Steps on the Proton Driver

I would like you to assemble and lead a team to achieve the goals recommended by the Fermilab Long Range Planning Committee relative to the Proton Driver, with an emphasis on the superconducting linac as suggested by that committee. For the purpose of this assignment I will define the Proton Driver project as a complete replacement of our current 400 MeV linac and 8 GeV Booster, accompanied by Main Injector upgrades, sufficient to enable the delivery of at least 0.5 MW of average beam power at 8 GeV, and 2.0 MW of beam power at 120 GeV. I am hopeful that the assignment described above can be completed by the end of 2004.

In particular I would like you to initiate and coordinate efforts in the following areas:

- **Preparation of documentation sufficient to establish mission need for the Proton Driver as defined by the Department of Energy CD-0 process.**
- **Development and documentation of the physics case.** I would like this to include both support for a forefront neutrino program at Fermilab in the decade of 2010 and beyond, and identification of other opportunities that could potentially be enabled with a Proton Driver facility.
- **Completion of comparably scoped cost estimates for the linac and synchrotron options based, to the extent practical, on a common basis of estimate and on common implementation strategies.**
  - –The cost estimates should specifically include modifications to the Main Injector required to meet the established 2 MW @ 120 GeV criterion.
  - –The cost estimates should assume a complete replacement of the existing linac.
  - –The implementation strategy should be based upon minimal disruption to the ongoing collider program (Run II and BTev).
  - –The goal is to understand the cost differential between the linac and synchrotron and what benefits are realized for the (presumably) higher cost.

- **Documentation and external review of accelerator physics and technological issues for both options**, specifically including anticipated beam loss and beam handling issues for both machines. The goal is to put the accelerator physics basis of the superconducting linac at the same level as the (more traditional) synchrotron-based solution.
- **Examination and documentation of the siting issues** associated with both machines, for both the baseline mission of providing Neutrino Super-Beams and for future development of facilities on the Fermilab site.
- **Development and elucidation of an overall strategy for implementing a Proton Driver** that is in concert with the shorter term plan of the existing Proton Source and Main Injector improvements being developed under the leadership of Eric Prebys.

•As with any such responsibility you may be asked from time to time to report on Proton Driver progress to various review committees, help with the lab's long range financial planning for such a project, and help inform the Fermilab User Community about the exciting physics prospects of such a facility.

In organizing and undertaking this assignment I would like to collaborate closely with interested parties in all our divisions and sections. I would further ask you to involve institutions outside of Fermilab who might have potential interests in either collaboration on development, construction, and operations of the Proton Driver itself or in the scientific research programs enabled by the facility.

I would suggest that a workshop or workshops exploring the accelerator physics and technologies, along with the scientific opportunities would be an important component in proceeding in this direction. The lab will be happy to support you in the arrangements of such workshop(s)

It is my intention that once this information is available the Fermilab directorate will carry out a review that will compare the two prospective Proton Driver technologies with the goal of identifying the option that is best for Fermilab. This will allow the laboratory to proceed expeditiously with a complete Conceptual Design Report for the selected option, along with cost estimates, resource loaded schedules and other required CD-1 documentation, following the establishment of mission need via a formal CD-0 from the Department of Energy.

Action to implement the vision for the future outlined by the Fermilab Long Range Planning Committee is important to securing a healthy and productive future for both Fermilab and for the U.S. The steps described here are an important component of identifying how to best structure Fermilab's future program in areas that address many of the most important questions in science over the coming decade. **Steve Holmes will serve as the Directorate point of contact on this activity**, and both Steve and I look forward to working closely with you, and the participating divisions, sections, and outside institutions on this.

What next ?

- **FLRPC PD meetings have now evolved into a series of regular Proton Driver R&D, Design, and PD Physics meetings**
  - AD,TD, PPD all have significant involvement
  - Meeting include:
    - PD Physics working groups
    - RF design and Beam dynamics
    - Cryogenics issues
    - Civil and Siting
    - Accelerator Physics Issues (e.g. H- stripping, etc.)
    - In the future… workshop, Cost & Schedule estimates, etc.
  - Enthusiasm! Lots of people joining the effort ~ 40-50
  - Bill will tell you more about the work plan…

CONCLUSIONS

- **It seems likely that a new intense proton source will be proposed for construction at FNAL in near future**
- **Similar in scope to the Main Injector Project (cost/schedule)**
- **A 8 GeV Synchrotron or a Superconducting Linac appear to be both technically possible. However the SCRF linac has many attractive features if it can be made affordable**
- **The FNAL management has requested that the 8 GeV linac design be developed including cost & schedule information so that a technology choice can be made**
- **A Technical Design Report will be developed in the next year for the chosen technology**
- **This will make it possible to submit a Proton Driver project to the DOE for approval and funding**